W91321-04-C-0023

LOGANEnergy Corp.

Camp Mabry PEM Project Final Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Camp Mabry ANGB, Austin, TX

April 3, 2007

Executive Summary

Under terms of its FY'03 DOD PEM Demonstration Contract with ERDC/CERL, LOGANEnergy in cooperation with Austin Energy installed and successfully operated one Plug Power GenSys 5kWe Combined Heat and Power fuel cell power plant at the Camp Mabry Army National Guard Base, located in Austin, TX. The site on the base selected for the one-year demonstration project was the Texas National Guard Museum. The unit was electrically configured to provide grid parallel service to the site. In addition, the unit was thermally integrated with a small HVAC desiccant air unit to provide seasonally warm or cool dry air to benefit moisture sensitive artifacts in the museum. The fuel cell was operational from October 20, 2005 to February 26, 2007. Based on Camp Mabry electric/gas rates and the fuel cell output, it is estimated that the project added $1,040.87 annual energy costs to Camp Mabry during the period of performance. The fuel cell hardware performed successfully; achieving 100% availability in eleven of the 17 operating months. The fuel cell will be removed and the site restored in April 2007. The Camp Mabry ANGB POC for this project is Michael Wolf who can be reached at the following address and phone number:
Email: mwolf@pollution.org
Phone:512.782.5001.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

LOGANEnergy Corp. Small Scale PEM 2004 Demonstration Project at Camp Mabry ANGB, Austin, TX

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 PAFC and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P LP Gas unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vinny Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Chris Davis	Keith Spitznagel
Title	Chief Operating Office	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	cdavis@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Chris Davis	Keith Spitznagel
Title	Chief Operating Office	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	cdavis@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022
Contract Value - $120,000

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Four-year PC25 PM Services Maintenance Agreement.
In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.
Contract Value - $52,000

Plug Power
Vinny Cassala
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1228

c) Contract: A Partners LLC Commercial Fuel Cell Project Design, Installation and 5-year service and maintenance agreement on 600kW UTC PC25 power block.

Contract # <u>A Partners LLC, 12/31/01</u>
Contract Value - $5,700,000

Mr. Ron Allison
A Partner LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

7.0 Host Facility Information

Camp Mabry, named after Brigadier General Woodford H. Mabry, the Adjutant General of Texas from January 23, 1891 to May 4, 1898, is the headquarters of the State Military Forces. The original 90 acres, located on an elevated plain overlooking the Colorado River about three miles northwest of the Capitol Building in Austin, was selected by a group of prominent citizens, businessmen, and Guardsmen. Governor J.S. Hogg accepted the site on behalf of the state in 1892.

Currently, the post houses the Texas Military Forces Academy, which is the second state building constructed, opened on June 15, 1884. The educational facility conducts the Officer Candidate School, the (NCO) Noncommissioned Officer Academy, Medical Specialist Course and numerous other specialized schools. Also located on the post is the Texas National Guard Museum (site of the demonstration project), the United States Property and Fiscal Office, one of two state Combined Support Maintenance Shops, the Texas National Guard Armory Board, the armory of the Headquarters of the 49th Armored Division, a troop medical clinic, a parachute packing and storehouse facility, plus numerous supply and warehouse facilities.

The electrical provider to Camp Mabry is Austin Energy and the natural gas provider is Santana Natural Gas.

8.0 Fuel Cell Installation

The fuel cell was installed on a pad at the rear of the Museum building, pictured at right, in a grid parallel configuration. The building's electrical service and natural gas service were conveniently located a short distance from the pad site. Because of the of the air dehumidification requirements of the facility to help preserve the artifacts on display, LOGAN installed a Munters desiccant unit to help lower the humidity of the interior spaces of the facility. This provided the opportunity to test a commercial desiccant system using waste heat from the fuel cell. It was hoped this approach would provide much higher thermal utilization in contrast to other projects where the heat transfer has typically occurred with a hot water tank.

Figure 1– View of the GenSys5C on its pad at the rear of the Museum building.

The fuel cell system installation required 102 man-hours over a three week period to complete. The fuel cell system was officially commissioned on October 25, 2005. The fuel cell typically operated at 2.5kW in a grid parallel configuration with a typical natural gas consumption of 0.33 standard cubic feet per hour (scfh) for the duration of the demonstration. Figures 2 and 3 show different views of the project during installation.

Figure 2 – Installation trenching for fuel, power and thermal recovery piping. Watt meter and service disconnect are bracketed to the front of the unit.

Figure 3 – Installation of a natural gas regulator and flow meter completes the fuel supply system.

Figure 4 – Photo of building penetrations to provide electrical and thermal energy to the interior service interfaces.

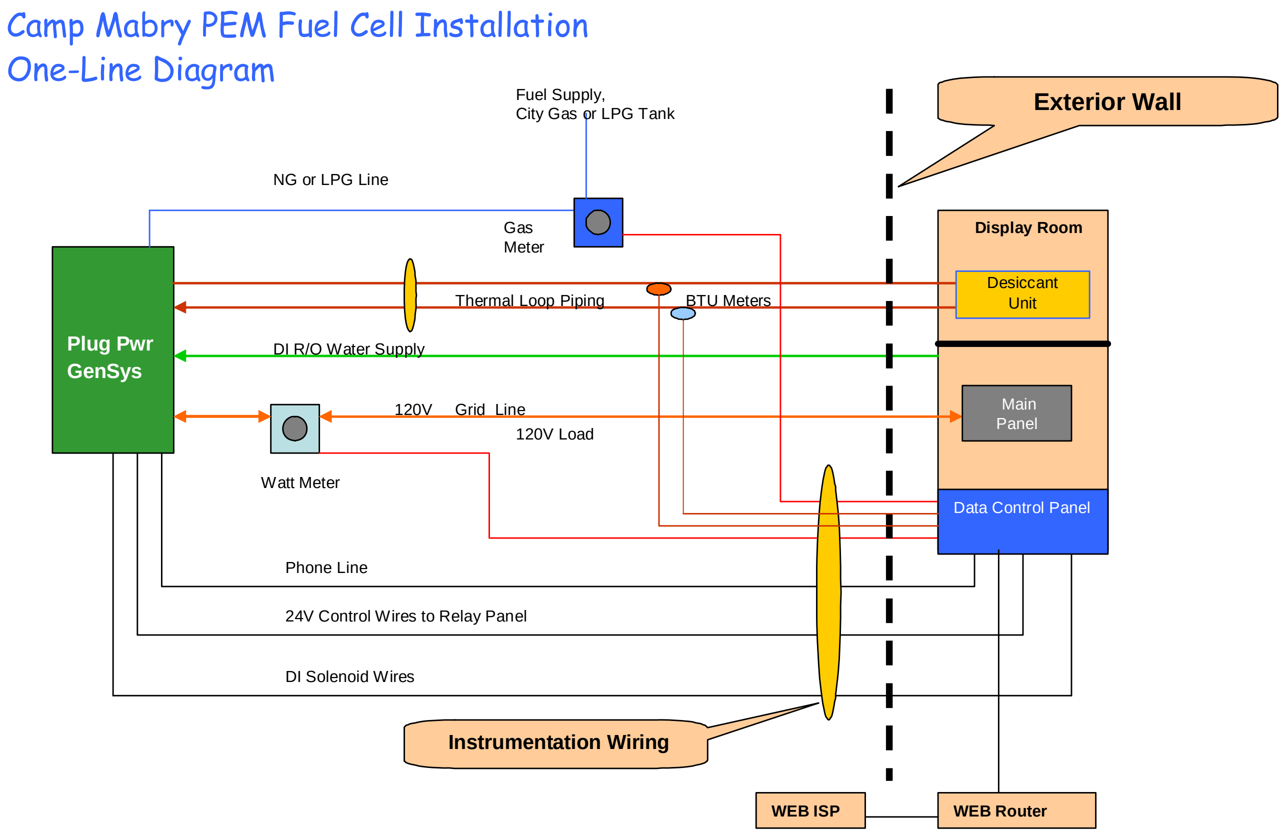


Figure 5 – Diagram of electrical, mechanical, thermal, and communications interfaces between the fuel cell and the host facility.

9.0 Electrical System

The Plug Power GenSys 5C PEM fuel cell power plant provided both gird parallel and grid independent operating configurations for site power management. This capability was an important milestone in the development of the GenSys5 as it approached product commercialization. The unit had a power output of 110/120 VAC at 60 Hz, and when necessary the voltage could be adjusted to 208vac or 220vac depending upon actual site conditions. At this site the unit was connected to the facility in a grid parallel configuration dispatching power at 2.5 kW for most of the period of performance. However, subject to the availability of additional funding the unit could operate at 5kW for three months to evaluate the thermal efficiency and output of the DryKor desiccant unit by providing more Btus from the fuel cell to the desiccant unit that would be available at the higher power setting.

Figure 6 – Photo of the electrical service closet showing open panel on the right where the fuel cell 110 volt conductor terminates at a 50 amp circuit breaker.

Figure 6 shows the electrical service panel, before fuel cell installation, where the fuel cell was electrically coupled to the base utility grid at a 50 amp circuit breaker. The electrical closet was conveniently located behind the exterior wall adjacent to the fuel cell pad site.

10.0 Thermal Recovery System

While operating at a set point of 2.5 kW, the GenSys5C had a heat rate 35,200Btu/H and offloaded approximately 7,800Btu/H to the internally mounted customer heat exchanger. In an ongoing attempt to develop a total fuel cell energy solution that optimized this waste heat opportunity, LOGAN installed a Munters Corp. H300 Cargocaire desiccant dehumidifier at this site. As Camp Mabry is located in the southern US where high humidity increases air-conditioning loads, adds to utility costs, and raises other indoor environmental concerns, LOGAN believed desiccant air-conditioning could be the best use of low quality waste heat from the fuel cell to combat these issues. The Museum had one small desiccant unit currently in service that provided dry indoor air to help preserve the shelf life of numerous items on display, so the idea of installing a second larger desiccant system to improve the indoor air quality in a second display room had great appeal. After reviewing the products offered by several manufacturers, LOGAN selected the Munters H300, which had a long operating life for humidity control at virtually any temperature with the following additional advantages:

- Efficient humidity control for applications including product drying, mold and mildew control, corrosion protection, storage and condensation control.
- Durable unitized body with welded aluminum construction.
- Easy access panel for inspection and maintenance.
- Simple ductwork connections.
- Compact, low profile design.
- Flow rates of 150-300 scfm.
- Nominal moisture removal; 9.1 lbs/hr at 75F, 50% RH at 300 scfm.
- Capable of processing saturated, conditioned or outside air.

Figure 7 is a close up of the Munters H300 unit installed at the Camp Mabry PEM demonstration site in Austin, TX. Figure 8 is a photo of the H300 providing dry air to the Vintage Apparel display in the Museum.

Figure 7 – Photo of the Munters H300 Desiccant unit installed at the Texas National Guard Museum, Camp Mabry, TX.

Figure 8 – Photo of the Munters H300 providing desiccated airflow to the Vintage Apparel display at the Museum.

11.0 Data Acquisition System

LOGAN Energy installed a Connected Energy Corporation web based SCADA system that provided high-speed access to real time monitoring of the power plant. The schematic drawing seen below describes the architecture of the CEC hardware that will support the project.

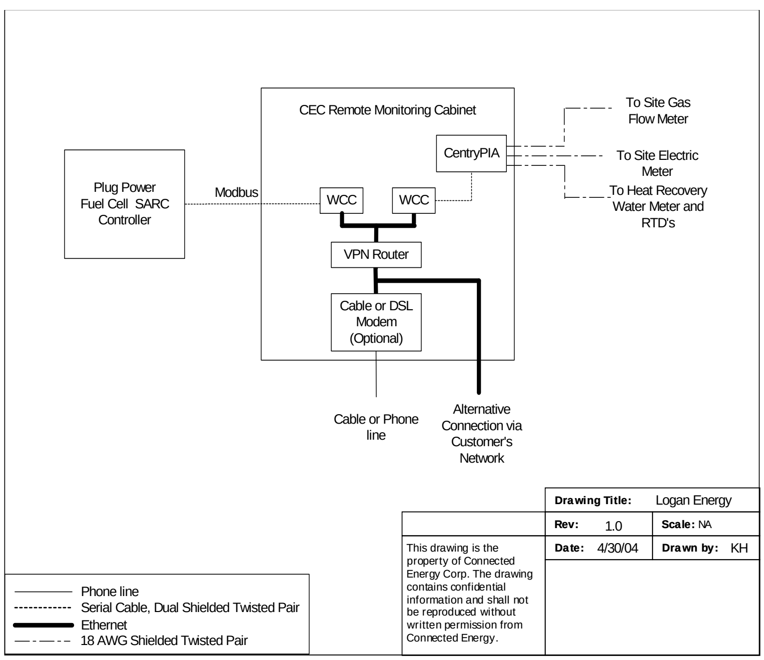


Figure 9 – CEC WEB enabled SCADA terminal hardware and architecture detail.

The system provided a comprehensive data acquisition solution and also incorporated remote control, alarming, notification, and reporting functions. The system could pick up and display a number of fuel cell operating parameters on functional display screens including kWH, cell stack voltage, and water management, as well as external instrumentation inputs including Btus, fuel flow, and thermal loop temperatures. CEC's Operations Control Center in Rochester, New York maintained connectivity by means of a Virtual Private Network that linked the fuel cell to the center.

For access to the demonstration data, as seen in Figure 10, use the following link and select Camp Mabry once at the Connected Energy site:
www.enerview.com

User: Logan.user
Password: guest

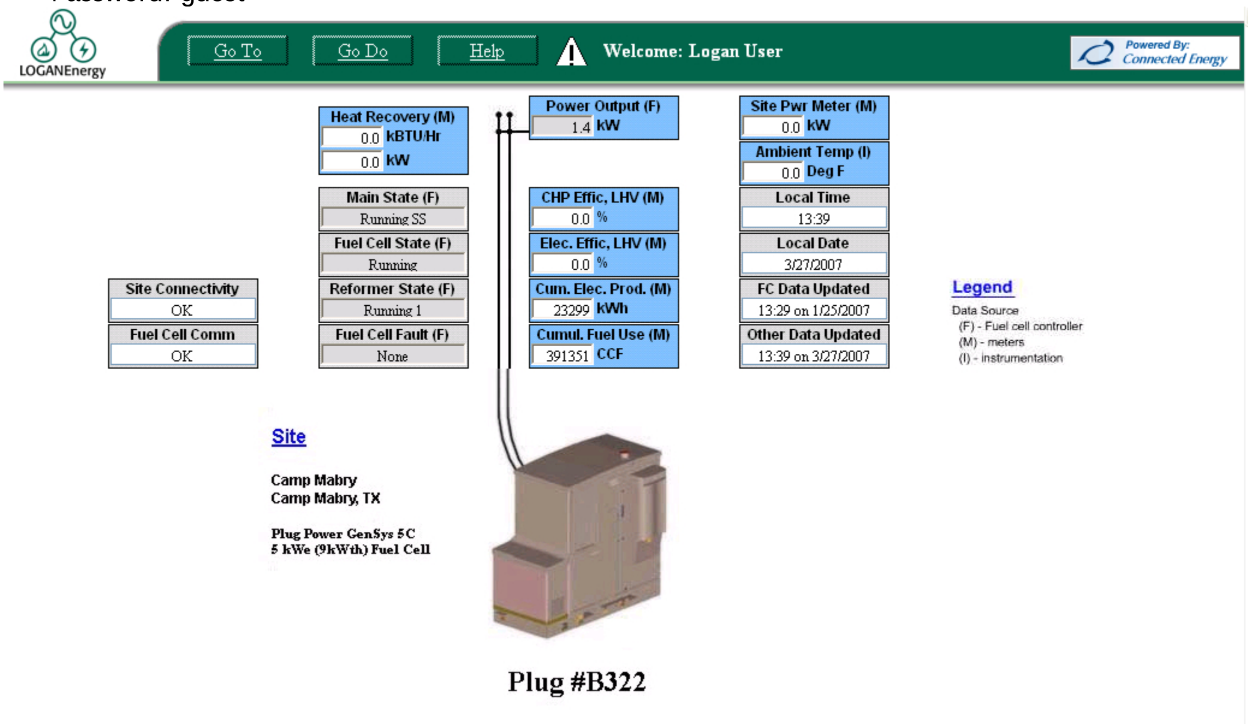


Figure 10 – CEC WEB Data Screen for S/N B322, the GenSys serial number of the Camp Mabry unit.

LOGAN procured high-speed access to the fuel cell router from a local ISP company. The base provided local dial tone to a phone jack in the Museum's electrical closet to provide communications with the fuel cell data modem.

12.0 Fuel Supply System

LOGAN connected the fuel cell gas piping into the existing natural gas service line pictured in Figure 3, and installed a flow meter to calculate fuel cell usage as detailed in Paragraph 8.0. A regulator at the fuel cell gas inlet maintained the correct fuel cell operating pressure at 14 inches water column. While operating at a set point of 2.5kWh the Gensys5C consumed 0.33 scfh of fuel.

13.0 Program Costs

Camp Mabry ANGB

Project Utility Rates								
1) Water (per 1,000 gallons)	$ 1.25							
2) Utility (per KWH)	$ 0.0625							
3) Natural Gas (per MCF)	$ 9.75							
First Cost				**Budgeted**		**Actual**		**Variance**
Plug Power 5 kW SU-1 & Munters Desiccant Dehumidifier			$	71,934.00	$	71,934.00	$	-
Shipping			$	2,400.00	$	2,078.00	$	322.00
Installation electrical			$	5,375.00	$	5,450.00	$	(75.00)
Installation mechanical & thermal			$	7,000.00	$	8,325.00	$	(1,325.00)
Watt Meter, Instrumentation, Web Package			$	11,090.00	$	11,270.00	$	(180.00)
Site Prep, labor materials			$	825.00	$	1,075.00	$	(250.00)
Technical Supervision/Start-up			$	2,500.00	$	2,500.00	$	-
Total			**$**	**101,124.00**	**$**	**102,632.00**	**$**	**(1,508.00)**
Assume Five Year Simple Payback			$	20,224.80	$	20,526.40		
Forcast Operating Expenses	Volume	$/Hr		$/ Yr				
Natural Gas Mcf/ hr @ 2.5kW	0.0330	$ 0.32	$	2,536.68				
Water Gallons per Year	14,016		$	17.52				
Total Annual Operating Cost					$	2,554.20		
Economic Summary								
Forcast Annual kWH		19710						
Annual Cost of Operating Power Plant	$	0.130	kWH					
Credit Annual Thermal Recovery Rate	$	(0.014)	kWH					
Project Net Operating Cost	$	0.1153	kWH					
Displaced Utility cost	$	0.0625	kWH					
Energy Savings (Cost)		($0.053)	kWH					
Annual Energy Savings (Cost)		($1,040.87)						

14.0 Milestones/Improvements

Several aspects of the Camp Mabry project provided unique experience beyond the mere demonstration of the fuel cell hardware. Achieving a successful demonstration at Camp Mabry broadens the fuel cell experience and provides added confidence that fuel cells can be adapted for other unique situations.

The local utility company, Austin Energy, took an active role in the initial fuel cell siting and preparation of plans. Austin Energy attended project meetings and was a positive influence in gaining the acceptance and confidence of the host site personnel at Camp Mabry.

The selected site was at a building which was originally built as a mess hall in 1918. Because of the age of the building, which qualifies it as a historical site, all construction affecting the building structure and aesthetics required special consideration and prior approval. The connection points for utilities, except for the electrical and thermal piping, were selected at nearby locations to avoid penetrations to the historic building. Thermal piping was routed along the exterior of the building without anchoring to the old masonry wall. Final penetration of the thermal piping was accomplished through an existing window by carefully removing glass panes which could be reinstalled at the completion of the fuel cell project.

The unique thermal application was to provide dehumidification for a room where vintage clothing is stored. Humidity control is important to the preservation of the museum artifacts. LOGANEnergy selected the Munters dehumidification hardware (as described in Section 10 above) to work with the fuel cell hardware. Anecdotal comments by museum personnel indicated they noticed and were pleased with the dehumidification results of the fuel cell and Munters combination.

15.0 Decommissioning/Removal/Site Restoration

Operation of the fuel cell ceased near the end of February 2007. Decommissioning and restoration of the site was scheduled for April 2007. In addition to the usual disconnection of utilities and landscape restoration, the window where thermal piping penetrations were made was restored to original condition.

16.0 Additional Research/Analysis

Analysis of the data shown in the Appendix indicates performance results for this fuel cell demonstration.

Total run hours reached 9861 hours over 17 operating months yielding an availability of 84%. However, eleven of the 17 months achieved 100% availability and an additional month was at 93%. The lower overall availability was greatly affected by one lengthy outage from 28 Jul to 7 Sep 2006.

Total electricity produced was 23,044 kWh which has a value of $1440 at the local grid price of $0.0625 per kWh. The intended operating set point for the fuel cell was 2.5 kW electrical output. Average output over the operating hours was 2.34 kW. The fuel usage was 297,669 scf which has a value of $2902 assuming a price of $0.00975 per SCF. The electrical efficiency (which began the early months slightly above 27%) averaged 24.4% over the life of the project.

Total heat recovery over the entire demonstration was over 28 million Btus. Over the 9661 hours of operation, this yields an average of 2909 Btus per hour – compared to nominal rated output of approximately 7800 Btus per hour when operating at 2.5kW electrical output. However, as can be seen in the monthly data and the air humidity performance graph, thermal usage varied widely from month to month. The overall efficiency (electrical plus thermal) averaged 33%.

Over the 9861 operating hours, the unit experienced 6 unscheduled outages; yielding a mean time between outage of 1643 hours. The 6 outages led to 1877 outage hours; yielding a mean time to repair (MTTR) of 313 hours. As mentioned above, one lengthy outage (approximately 996 hours) affected the MTTR. A significant portion of this longest outage was associated with scheduling difficulties in getting repair personnel to the site. Ignoring the one unusually long outage, the remaining five outages averaged a MTTR of 176 hours.

Review of the maintenance logs (in Appendix 3) revealed no particularly noteworthy trends or specific, repetitive problems except to note that none of the issues were related to fuel cell stack problems. The core fuel cell technology performed well and as expected. Other issues noted in the maintenance logs (typically causing what is labeled an "ESTOP SHUTDOWN") involved relay replacements, low battery voltage, low water flow, and filter replacements. While so few log items on this project do not lead to identification of conclusive trends, the maintenance items experienced on this project were common to LOGANEnergy experiences at other sites using this hardware.

17.0 Conclusions/Summary

The Museum Building at Camp Mabry, near Austin, TX, provided an interesting thermal application for a successful demonstration of a Plug Power 5 kW PEM fuel cell. Project development occurred in cooperation with the local utility company, Austin Energy. The minor construction associated with installing the fuel cell required some extra consideration because of the historic building site.

The first-time (for LOGANEnergy) application of a Munters dehumidification unit resulted in satisfactory performance. However, as is common to many cogeneration projects, full utilization of available thermal energy proved difficult. At times when the dehumidification load was substantial, the unit performed nicely. Building occupants commented and appreciated the dehumidification that is important for storage of museum artifacts.

The location of the fuel cell on an unpaved area at the rear of the building provided for routine construction/trenching without major obstacles. Penetration of the historic building masonry was avoided by taking thermal piping through an existing window which could be restored at the end of the demonstration.

Project economics (as provided in section 13) indicate a net operating cost of $0.1152 per kWh which would be comparable or less than electric utility rates in many U.S. locations. However, with the local rate of approximately $0.0625, this project was economically challenged. The initial hardware cost of nearly $72K for the fuel cell and dehumidifier units would need to be reduced significantly to produce an economically viable project for this region at the current electricity rates.

Fuel cell hardware performance was reasonably good for this demonstrations site. Electrical output, thermal output, fuel usage, and efficiency were at expected levels for the Plug Power hardware. Six unscheduled outages over the demonstration period spanning 17 months resulted in a mean time between outage of 1643 hours. Eleven of the months achieved 100% availability for the entire month.

Appendix

1. Performance Graphs

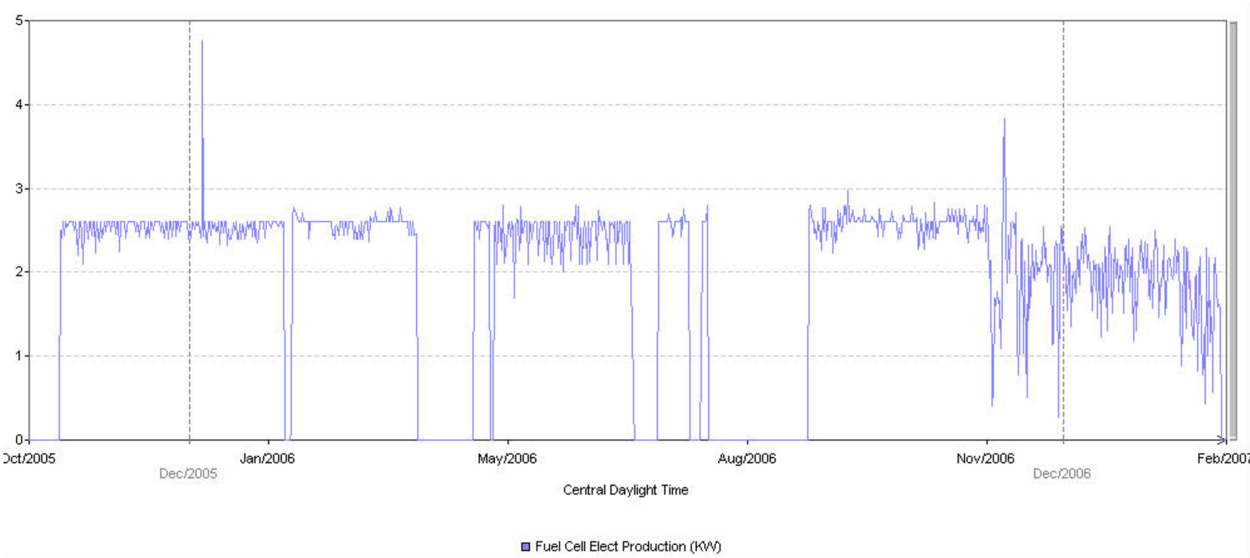


Figure 11 – **Electrical Output** (kW)
20 Oct 2005 – 26 Feb 2007

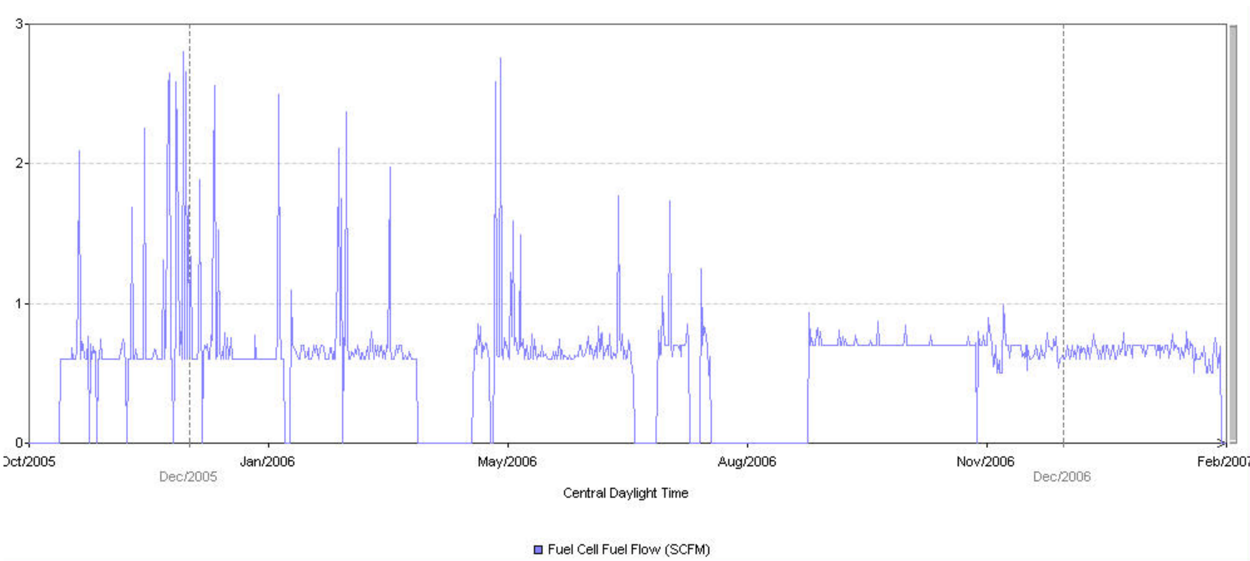


Figure 12 – **Fuel Flow** (SCF per Hr)
20 Oct 2005 – 26 Feb 2007

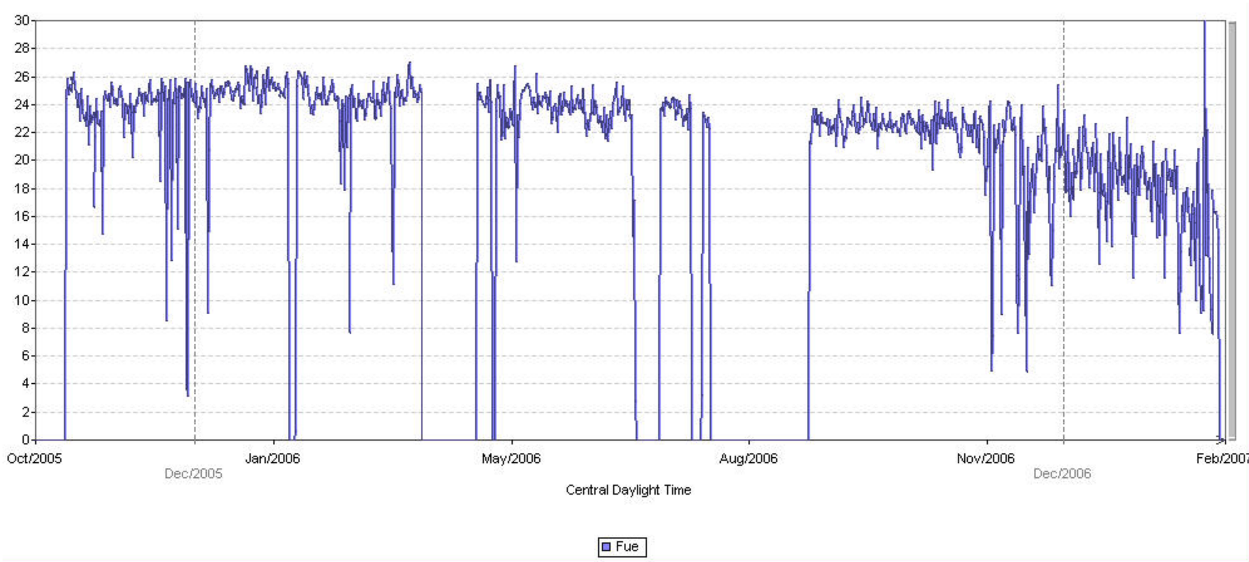


Figure 13 – **Electrical Efficiency** (%)
20 Oct 2005 – 26 Feb 2007

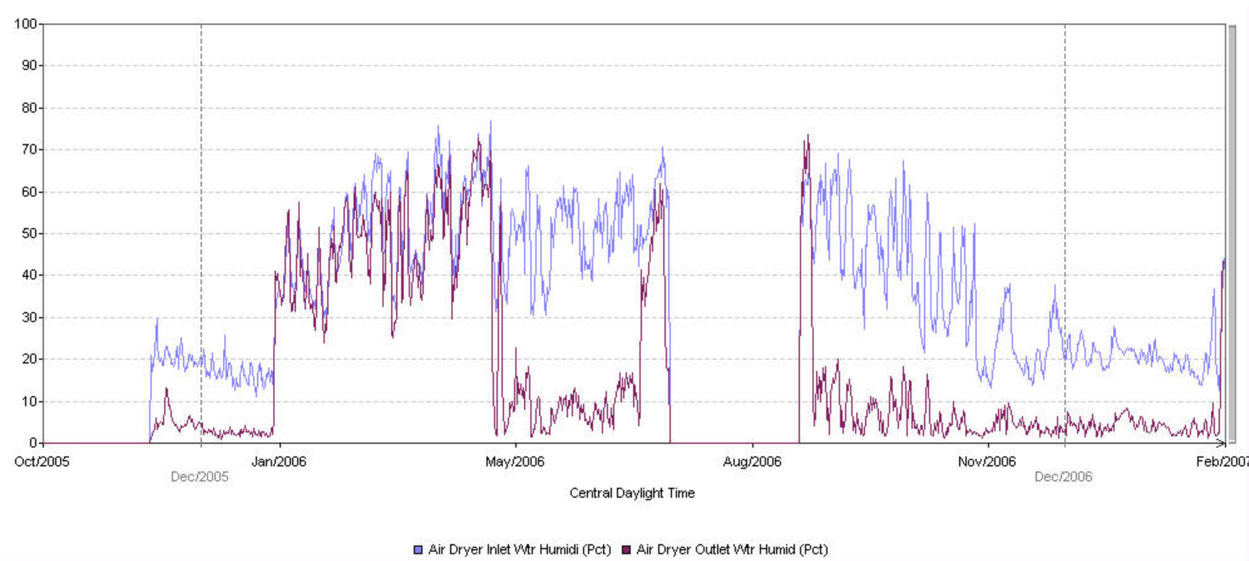


Figure 14 – **Air Humidity** (%)
Entering & Exiting Dehumidifier
20 Oct 2005 – 26 Feb 2007

2. Monthly Performance Data

Month	Run Time (Hrs)	Time in Period (Hrs)	Availability (%)	Energy Produced (kWe-hrs AC)	Avg Output (kW)	Fuel Usage (SCF)	Electric Efficiency (%)	Thermal Heat Recovery (BTUs)	Thermal Efficiency (%)	Overall Efficiency (%)	Number of Unscheduled Outages	Unscheduled Outage Hours
Oct-05	138	138	100%	344.0	2.49	4274	27.2%	0	0.0%	27%	0	0
Nov-05	720	720	100%	1752.0	2.43	21713	27.2%	0	0.0%	27%	0	0
Dec-05	744	744	100%	1878.3	2.52	23234	27.3%	4094500	17.4%	45%	0	0
Jan-06	744	744	100%	1847.0	2.48	22596	27.6%	12743300	55.8%	83%	0	0
Feb-06	624	672	93%	1562.6	2.50	19584	26.9%	0	0.0%	27%	1	48
Mar-06	744	744	100%	1674.0	2.25	21045	26.8%	0	0.0%	27%	0	0
Apr-06	239	720	33%	599.0	2.51	7637	26.5%	2398000	31.0%	58%	1	481
May-06	744	744	100%	1831.7	2.46	24529	25.2%	1599730	6.4%	32%	0	0
Jun-06	613	720	85%	1455.8	2.37	19399	25.3%	1171880	6.0%	31%	1	107
Jul-06	402	744	54%	1016	2.53	13148	26.1%	0	0.0%	26%	1	342
Aug-06		744	0%		0.00	0		0				744
Sep-06	567	720	79%	1446.3	2.55	19480	25.1%	298685	1.5%	27%	1	153
Oct-06	744	744	100%	1879.8	2.53	25625	24.8%	1422081	5.5%	30%	0	0
Nov-06	718	720	100%	1714.8	2.39	24748	23.4%	1379068	5.5%	29%	1	2
Dec-06	744	744	100%	1511.7	2.03	24664	20.7%	1464497	5.9%	27%	0	0
Jan-07	744	744	100%	1507.7	2.03	25727	19.8%	1536871	5.9%	26%	0	0
Feb-07	632	632	100%	1023.0	1.62	265	16.4%			16%		

Running Totals

	Total Run Time	Total Hours in Period	Total Availibility	Total Energy Produced	Total Avg Output	Total Fuel Usage	Avg Electric Efficiency	Total Thermal Heat Recovery	Avg Thermal Efficiency	Avg Overall Efficiency	Total Outages	Total Hours
	9861	11738	84%	23044	2.34	297669	24.4%	28108612	8.7%	33%	6	1877

3. Maintenance Logs

Report Date: 5/5/06 **Technician Initials:** WH **FC Serial #:** SU1 B322
Event: K1 RELAY CHANGEOUT
Total Hours On-Site: 2
Mileage: N/A
Type of Outage: ☑ Scheduled ☐ Unscheduled
Failure Date/Time: 5/5/06 12:00
Restart Date/Time: 5/5/06 13:00:00 PM
Total Hours Unavailable: #VALUE!

Meter Readings:

Gas	34532.92
Electric	10004
BTU	
FC Operating Hours	4005.58

Problem Description:
REPLACED K1 RELAY AT REQUEST OF PLUG POWER. SAFETY ISSUE WITH K1 RELAY NOT OPERATING PROPERLY.
FUEL CELL WORKING FINE BEFORE AND AFTER RELAY CHANGEOUT.
TOTAL TIME UNIT OFF: ONE HOUR
Service Performed or Corrective Action Taken: REPLACED K1 RELAY

Report Date: 7/6/06 **Technician Initials:** WH **FC Serial #:** SU1 B322
Event: ESTOP SHUTDOWN - KW OUTPUT SWINGING 0-2500 PRIOR TO SHUTDOWN
Total Hours On-Site: 8
Mileage: N/A
Type of Outage: ☐ Scheduled ☑ Unscheduled
Failure Date/Time: 6/26/06 12:00
Restart Date/Time: 7/6/06 12:00
Total Hours Unavailable: 240

Meter Readings:

Gas	46,215.26
Electric	13007
BTU	
FC Operating Hours	5246.59

Problem Description:
FOUND 50 AMP FC BKR TRIPPED IN MAIN (GRID) PANEL AND ALL 4 BATTERIES @ 5VDC EACH.

Service Performed or Corrective Action Taken:
REPLACED 50A BKR WITH A 60A BKR AND REPLACED ALL 4 BATTERIES. TOPPED OFF THERMINOL AND SYSTEM COOLANT. RESTARTED FUEL CELL AND

Report Date: 9/1/06 **Technician Initials:** WH **FC Serial #:** SU1 B322
Event: ESTOP SHUTDOWN
Total Hours On-Site: 4
Mileage: 1800
Type of Outage: ☐ Scheduled ☑ Unscheduled
Failure Date/Time: 7/28/06 0:00
Restart Date/Time: N/A
Total Hours Unavailable: #VALUE!

Meter Readings:

Gas	226,632 (CE)
Electric	14246 (CE)
BTU	
FC Operating Hours	5652

Problem Description: FOUND WATER SYSTEM NOT FUNCTIONING. RO WASTE VALVE WAS TURNED OFF INSIDE FILTER/RO BOX. NO RO PRODUCT WATER

Service Performed or Corrective Action Taken: REPLACED CARBON AND RO FILTERS. CONDITIONED RO FILTER AND ADJUSTED
WILL HAVE TO WAIT UNTIL NEXT WEEK TO START SYSTEM. NO FUEL AVAILABLE, GAS SYSTEM BEING TESTED BY BASE MAINTENANCE.

Report Date: 9/7/06 **Technician Initials:** WH **FC Serial #:** SU1 B322
Event: ESTOP SHUTDOWN LOSS OF WATER, RESTART.
Total Hours On-Site: 8
Mileage: 1800
Type of Outage: ☐ Scheduled ☐ Unscheduled
Failure Date/Time: 7/28/06 0:00
Restart Date/Time: 9/7/06 0:00
Total Hours Unavailable: 984

Meter Readings:

Gas	226,632 (CE)
Electric	14246 (CE)
BTU	
FC Operating Hours	5652

Problem Description: LOSS OF WATER DUE TO VALVE TAMPERING. ALSO LOSS OF CONNECTED ENERGY INSTRUMENT READINGS AND
LOW HEAT RECOVERY FLOW. RESTART SYSTEM.

Service Performed or Corrective Action Taken: REPLACED CARBON & RO FILTERS, ADJUSTED FLOW. FOUND SEVERAL LOOSE
CONNECTIONS IN CE BOX & TIGHTENED. REPLACED HEAT RECOVERY PUMP WITH LARGER TACO PUMP, THIS INCREASED HR FLOW FROM 0.4
TO 1.1 GPM. REFILLED HR SYSTEM AND REMOVED AIR. STARTED AND MONITORED FUEL CELL. ALL OK.

Report Date: 9/27/06 **Technician Initials:** WH **FC Serial #:** 322

Event: CONNECTED ENERGY HEAT RECOVERY DATA NOT RECORDING
Total Hours On-Site: 4
Mileage: 1800

Type of Outage:
- [ ] Scheduled
- [x] Unscheduled

Failure Date/Time: 9/27/06 0:00
Restart Date/Time: 9/27/06 0:00
Total Hours Unavailable: 0

Meter Readings:

Gas	
Electric	
BTU	
FC Operating Hours	

Problem Description: **CONNECTED ENERGY HEAT RECOVERY DATA NOT RECORDING**
SUSPECT HEAT RECOVERY OUTLET WATER TEMPERATURE TRANSMITTER FAULTY

Service Performed or Corrective Action Taken: TROUBLESHOT INLET & OUTLET HR TEMP TRANSMITTERS. FOUND FAULTY RTD WHICH INPUTS TEMP TRANSMITTER. REPLACED RTD. ALSO FOUND CATHODE AIR INLET (PRE-SNORKEL) FILTER MISSING FROM FACTORY. INSTALLED NEW FILTER AND CLEANED SARC/CNTL ENCL. FILTER.

Report Date: 11/27/06 **Technician Initials:** WH **FC Serial #:** SU1 B322

Event: SULFER BREAKTHROUGH, DESULFERIZATION CANISTER REPLACEMENT
Total Hours On-Site: 5
Mileage: 1800

Type of Outage:
- [ ] Scheduled
- [x] Unscheduled

Failure Date/Time: 11/27/06 14:00
Restart Date/Time: 11/27/06 17:00
Total Hours Unavailable: 3

Meter Readings:

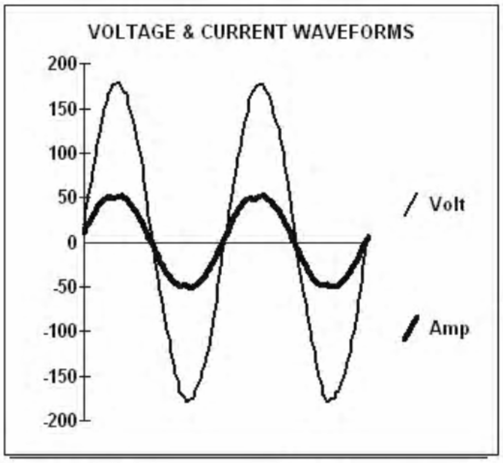
Gas	)5932(CE); 3,304,000(MT(
Electric	19040(CE); 19,650(MTR)
BTU	
FC Operating Hours	7589.65; 18931KWH

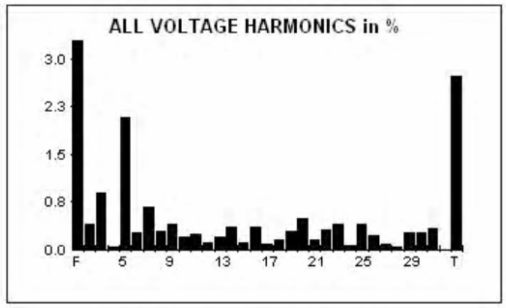
Problem Description: **SULFER BREAKTHROUGH CAUSING KW SWINGS**
FOUND SYSTEM HAD NOT HAD 12,000 HOUR MAINTENANCE AND SULFER BREAKTHROUGH OCCURRING. UNIT CONTINUED TO RUN WITH KW SWING UNTIL UNIT SHUTDOWN TO REPLACE DESULFERIZATION CANISTER.

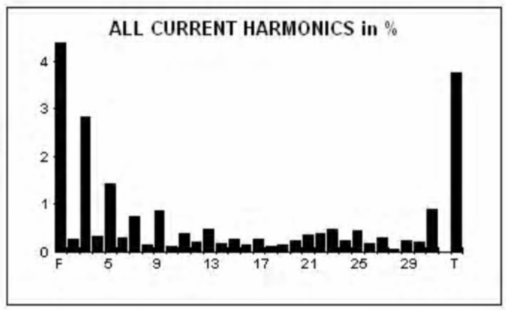
Service Performed or Corrective Action Taken: REPLACED DESULFERIZATION CANISTER, DE-IONIZATION FILTER & O-RINGS, RESTARTED MACHINE, RAN AT 3.5 KW OVERNIGHT TO CLEAN UP REFORMER CATALYST. STACK AND REFORMER LOOKED GOOD NEXT DAY SO LOWERED TO 2.5 KW. ALSO TOPPED OFF HEAT RECOVERY GLYCOL LOOP. NOTE: THIS SYSTEM STILL RUNNING WELL WITH ORIGINAL STACK!

4. Electrical Harmonics Measurements

Amprobe HarmonaLink II Power Waveform Analysis







Working Pwr	4.69 KW
Reactive Pwr	189.18 VAR Lead
Apparent Pwr	4.69 KVA
Displacement Pwr	224.59 dVA
True Power Factor	1.00 PF
Displacement PF	1.00 dPF

VOLTAGE ODD HARMONICS

H	%	RMS	Angle
1	100.0	125.13	+0
3	0.9	1.12	+116
5	2.1	2.59	+109
7	0.7	.83	+163
9	0.4	.50	-88
11	0.2	.30	-17
13	0.2	.25	+15
15	0.1	.13	-35
17	0	0	
19	0.3	.34	-148
21	0.2	.20	-142
23	0.4	.50	+118
25	0.4	.49	-103
27	0	0	
29	0.3	.34	-3
31	0.3	.42	-59
Trip.	1.1	1.36	
Odd	2.5	3.17	
Even	1.0	1.30	
THD	2.7	3.43	

CURRENT ODD HARMONICS

H	%	RMS	Angle
1	100.0	37.14	+0
3	2.8	1.06	+34
5	1.4	.53	-121
7	0.7	.27	+119
9	0.9	.32	-63
11	0.4	.14	+119
13	0.5	.18	-3
15	0.3	.09	-169
17	0.3	.10	+72
19	0.1	.05	-47
21	0.4	.13	+138
23	0.5	.18	+127
25	0.4	.16	-109
27	0.3	.10	+141
29	0.2	.08	-114
31	0.9	.33	-89
Trip.	3.1	1.14	
Odd	3.7	1.36	
Even	0.8	.31	
THD	3.76	1.39	

TOTALS	Voltage	Current
Total	125.17	37.17 rms
Peak	178.99	51.59
Avg.	112.56	33.69
DC	.23	.61
Crest	1.43	1.39
Form	1.11	1.10
F Freq	60.04	60.06 Hz
Fund.	125.13	37.14 rms
Harm.	3.43	1.39 rms
THD %	2.74	3.8%
K Fctr	1.09	1.16